THURSDAY, JUNE 2, 1892.

## THE GRAMMAR OF SCIENCE.

*The Grammar of Science.* By Karl Pearson, M.A., Sir Thomas Gresham's Professor of Geometry. "The Contemporary Science Series." (London: Walter Scott, 1892.)

ONE chief merit of this book is its exposition of the meaning of scientific law. There still exists, unfortunately, a type of mind which delights in such phrases as "the reign of law," the "immutable laws of Nature," and so on. The truly scientific mind has, however, been long familiar with the truth that a so-called law of Nature is simply a convenient formula for the co-ordination of a certain range of phenomena. It is this which Prof. Pearson so emphatically, if somewhat redundantly, expounds in the earlier chapters of the "Grammar." As he delights in putting it, a scientific law is a description in mental shorthand of certain sequences of sense-impressions. Through these sense-impressions alone can we gain any knowledge of what we are accustomed to call the external world. Thus the Universe as pictured by the scientific mind is a purely mental product. We can assert, scientifically, nothing regarding its constitution other than what we may validly infer from our perceptions and the conceptions based on these; and even then we must never forget that the reality to us is conditioned wholly by our powers of perception. This is the grand argument of the grammarian of science.

In developing his theme he introduces not a few interesting questions and analogies. Take, for example, his comparison of the brain to a telephone exchange. Here Reason, presiding as clerk, finds by experience that a certain subscriber always desires to correspond with a certain other subscriber. As soon as the call-bell from the former sounds, the clerk mechanically links him to the latter. "This corresponds to an habitual exertion following unconsciously on a sense-impression." Other analogies are obvious. Now, just as the clerk would obtain a very scrappy knowledge of the outside world if he had to trust simply to the messages which stream past him through the exchange, so (it is suggested) the picture our mind forms of the external world acting upon us through our sense-impressions may be very wide of the reality. Of course analogies must not be pressed too far. Yet it does seem that this analogy of the telephone exchange could be worked out most consistently by the despised teleologist. To Sir Thomas Gresham's Professor of Geometry, however, a telephone exchange evolving its own clerk is as simple a matter as an uninterrupted stream of sense-impressions creating Spencerianly a consciousness.

But Prof. Pearson is no mere preacher of familiar doctrines. He is a second Hercules, self-appointed to clear the scientific stables of all materialistic and metaphysical rubbish. He labours at the task of proving how illogical is the mind that passes to "the beyond" of the sense-impressions and the conceptions directly based on these. Thus he argues that, because the Universe is known only as our own mental product, we have no right to infer a mind in or above Nature as an explanation of the universality of the scientific law. Nevertheless, it behoves him to find a rational substitute for the law of continuity on which the authors of the Unseen Universe build their edifice. Consequently on p. 121 we read:—

> "It is therefore not surprising that normal human beings perceive the same world of phenomena, and reflect upon it in much the same manner."

Why not surprising? Because, as we learn from the preceding sentence, human beings "in the normal civilized condition have perceptions and reflective faculties nearly akin." But why nearly akin? Well, it has to be so because "the world of phenomena must be practically the same for all normal human beings," or the universality of scientific law will fail. Putting in the definitions of the terms in the first quoted sentence we read:—It is therefore not surprising that beings, who have perceptive and reflective faculties capable only of producing practically the same world of phenomena, perceive the same world of phenomena and reflect upon it in much the same manner. In this exquisite cycle of reasoning what, we ask, is the logical work done?

Our grammarian poses as a logician of the straitest sect. Bad logic he cannot abide; and since apparently he cannot read a book without seeing the cloven hoof he must have rather a sorry time of it. His own logic must, of course, be flawless. So, when we are told with reiterated emphasis that time and space are but modes of perception, and are then asked to imagine our Universe in time and space without a consciousness to perceive it, we feel a sinking at the heart. Things, we find, can exist under certain modes of a non-existent perception. The laws of Nature are a mental product; yet a certain evolution theory logically based upon them quite eliminates the mental. We are reminded of the sagacious carpenter who sat high and lifted up on the end of the bracket beam he was sawing through; or of the small boy who spent his wealth in buying a purse to hold it in.

A large section of Prof. Pearson's book is destructive criticism. "Cause," "Force," and "Matter" are as red rags to him. Cursed be he who uses these words without clearly defining, in footnote or otherwise, their significance according to the definitions given in the "Grammar of Science." Sir Isaac Newton is severely visited for his sins; Thomson and Tait get a thorough drubbing; Maxwell is censured for his bad logic; and Prof. Tait especially, if we are to judge of him through the medium of this book, must have done more to retard the progress of science than any other single man of the century. Sound criticism is always welcome; but "smart" controversy of the hustings type is rarely sound in print. As a fair example of our grammarian's method, take his critique of Maxwell's descriptions (not definitions be it noted) of the intimate relation between matter and energy. Maxwell says, "We are acquainted with matter only as that which may have energy communicated to it from other matter, &c.," and "Energy, on the other hand, we know only as that which . . . is continually passing from one portion of matter to another." These are represented as meaning that "the only way in which we can understand matter is through the energy which it transfers," and "the only way to understand energy is through matter. Matter has been defined in terms of energy, and energy again in terms of matter." By what logic or grammar can *understand* be substituted for *are acquainted with* or *know;* and by what right is a description twisted into a definition? Words in their usual meanings may, however, be of little consequence to a writer who persists in using the English word *resume* in the French sense. It seems to us that Prof. Pearson has altogether missed the significance of the word "objective" as used by Prof. Tait, to whom, as everyone knows or should know, we owe the first clear presentation of the dogma that force has no objective existence. At any rate, we are surprised to find in the "Grammar of Science" no distinct reference to the two grand principles of all science—to wit, the conservation of matter and the conservation of energy. This omission by an avowed writer on the principles of science is certainly matter of surprise. As regards the views of force expounded in the book, the author is simply a disciple of Prof. Tait. If not, he must regard Tait as "that worst of plagiarists"—the man who made the discovery before he did. Prof. Pearson has, indeed, a certain fatality for having dealings with that most unsatisfactory kind of plagiarism. In Tait's "Properties of Matter," first edition (1885), paragraph 162, are written these words:—

> "Sir W. Thomson has shown that if space be filled with an incompressible fluid, which comes into existence in fresh quantities at the surface of every particle of matter, at a rate proportional to its mass, and is swallowed up at an infinite distance, or, if each particle of matter constantly swallows up an amount proportional to its mass, a constant supply being kept up from an infinite distance,—in either case gravitation would be accounted for."

If this is not *essentially* the theory of "ether-squirts" which "the author has ventured to put forward," what then is the ether-squirt? The quotation just given occurs in Tait's seventh chapter, which, being empty of "red rags," probably failed to come within Prof. Pearson's sphere of perception.

Be it noted that we do not criticize our author's views as to the significance of such words as force and cause; but we cannot say we fancy his critical tone towards others. He himself uses the phrase "acceleration of A due to B," but warns the reader in a footnote against taking the phrase in its literal sense; yet anybody else from Newton down the centuries who has dared to use similar phrases is sneered at as a searcher after the unknowable "why."

For example, in his criticism of Newton's first law of motion, what right has he to say that Newton "was thinking of force in the sense of mediæval metaphysics as a cause of change in motion"? What is the perceptual or conceptual basis of this assumed certitude? Newton was probably thinking of *vis impressa*, the very grammatical form of which shows that there was nothing ultimate implied in the *vis*. After discussing the various kinds of *vires* that have to be dealt with, and pointing out clearly by definitions and descriptions their precise meanings, Newton concludes one paragraph in these words:—

> "*Mathematicus duntaxat est hic conceptus: Nam virium causas et sedes physicas jam non expendo.*"

Then a little further on we read:—

> "*Has vires non physice sed mathematice tantum considerando. Unde caveat lector, ne per hujusmodi voces cogitet me speciem vel modum actionis causamve aut rationem physicam alicubi definire vel centris (quæ sunt puncta mathematica) vires vere et physice tribuere; si forte aut centra trahere, aut vires centrorum esse dixero.*"

Can it be that Prof. Pearson has never read Newton's "Principia," and has he forgotten that the complete title is "Philosophiæ Naturalis Principia Mathematica"? To insinuate that Newton's laws of motion (which, it should never be forgot, are intimately associated with the *Definitiones*) are incomplete because they may not possibly apply to corpuscles other than those of "gross" matter, to corpuscles of all imaginable types in short, implies a complete misapprehension of the whole purpose and scope of the "Principia." Again, our grammarian pounces upon the word "body," or *corpus*, as used by Newton, who should at least have used particle or corpuscle. In Definition I. will be found the meaning intended by Newton to be attached to the word *corpus;* but in any case the whole phraseology of the first law is quite intelligible to the candid mind. Newton had a fine faith in his reader. He gave the *Definitiones* and *Axiomata* in a form that appealed at once to the common experiences of thoughtful minds; and what more do we need?

Prof. Pearson characterizes the second law as a "veritable metaphysical somersault. How the imperceptible cause of change in motion can be applied in a straight line surpasses comprehension, &c." This may be smart, but is it relevant? Where does Newton define *Vis Motrix* as the "imperceptible cause of change in motion"?

We have not space to enter upon a discussion of the five laws of motion suggested by Sir Thomas Gresham's Professor of Geometry as a true non-metaphysical basis for all science. They are good enough in their way; but they seem to lack that direct reference to ordinary facts of experience which is a desideratum of all physical axioms. They begin with a dance of molecules and end with a measure of force Their ostensible merits are their logical form and their comprehensiveness—ether corpuscles as well as matter corpuscles being nominally included. Yet we have to confess our inability to see that these laws of motion can effect more than Newton's. Dynamics, in all its branches, still is Newtonian.

In its discussion of the meaning of scientific law, in its presentation of kinematic principles, and in its treatment of certain present-day speculations as to the constitution of matter and of ether, Prof. Pearson's book is at once interesting and instructive. There is much in it fitted to arrest the materialistic tendency of many who are devotees of science to the exclusion of all other intellectual activities. Yet its own conclusions are as materialistic as they well can be. The automaton theory of the human will, and the spontaneous generation of life, are articles of its creed. In the second last chapter we are treated to a choice collection of charming dogmatisms. Perhaps the most charming of all is the author's "unwavering belief" that the hitherto undiscovered formulæ which are to make history a science "can hardly be other than those which so effectually describe the relations of organic to organic and of organic to inorganic phenomena in the earlier phases of their development." A curious assertion, surely, for one to make who objects to Newton's laws of motion because they don't include imaginable but still unknown types of corpuscular motion. The particular value, however, of this confession of faith is that it enables the confessor to convict of scientific heresy Prof. Robertson Smith and all others who cannot regard it as other than an assumption. To believe as Prof. Pearson believes is to believe scientifically; all other belief is rotten. As the "auld licht" dame said when telling over the number of the elect, "Ay, there's jist me and John; and whiles I'm no that sure o' John." C. G. K.

---

## *THE TEACHING OF THE PRINCIPLES OF CHEMISTRY.*

*Laboratory Practice: A Series of Experiments on the Fundamental Principles of Chemistry.* A Companion Volume to "The New Chemistry." By Josiah Parsons Cooke, LL.D., Erving Professor, and Director of the Chemical Laboratory, Harvard University. Pp. 192. (London: Kegan Paul, Trench, Trübner, and Co., 1892.)

THIS little book represents another attempt to teach the theory of chemistry upon the basis of a narrowly restricted experience of facts and phenomena. Whether this is possible is a question debatable, and still, in fact, debated among teachers. That it is possible to make the study of chemistry by young people, as a form of intellectual exercise, more useful than has usually been the case there can be no doubt, and that much instruction could be got out of a course such as this which is indicated in Prof. Cooke's little work is certain. The book appears to be intended as a guide for the teacher as much as for the pupil, and much would depend upon the qualifications of the former for the work of demonstration and exposition. It contains directions for the performance of a system of experiments; and to do justice to the system the teacher ought carefully to study the instructions given in the introduction, and to act upon them. And to those who know anything of the manner in which chemistry is too often taught in the schools of this country, either by the visiting "science teacher," who knows little, or by the mathematical master, who usually knows nothing at all about the subject, such remarks as the following, taken from the introduction, will seem particularly welcome and appropriate.

The author says:

> "Experiments are only of value as parts of a course of instruction logically followed out from beginning to end. In such a course there must be necessarily a great deal to be filled out by the teacher, and this can vastly better be taught from his lips, with such illustrations as he can command, than from any books."

And again,

> "The best apparatus will be of no use unless the teacher stands before it and speaks to his pupils out of the fulness of his own knowledge. This is an essential condition of success, and without it the experimental method should never be attempted."

But after these things have all been duly noted and acted upon, a glance at the table of contents is apt to raise a doubt whether after all the erection of so large a superstructure is justifiable or practicable upon foundations so slender. The book begins at p. 13, and thence to p. 52, with the exception of three or four pages about water, the whole is devoted to the physical properties of liquids and solids represented by water and air. Then we come to oxygen, hydrogen, sulphur and its oxides, chlorine, carbon and the oxides of carbon, ethylene, nitrogen, nitric acid, ammonia, magnesium, zinc, sodium, copper, and iron, all of which are included in the fifty pages following. Then comes a chapter on general principles, a third on molecules and atoms, followed by chapters on symbols and nomenclature, molecular structure, and thermal relations.

This is not the first book which has appeared with similar objects. In this country there have been Prof. Ramsay's little book on "Chemical Theory," Muir and Carnegie's "Practical Chemistry," Shenstone's "Practical Introduction to Chemistry," and probably others, which seem to aim at dealing with chemistry in the same kind of way, which is intended to be a way of pleasantness and a short cut to rather exalted territory. The road, however, is bordered by precipices unseen by the young traveller.

The advocates of this kind of system, which consists in passing from one or two rough experiments, or observations, direct to great generalizations, anticipate great things from its general adoption. All the rising generation who come under its influence are to possess greatly developed powers of observation and reasoning. Some of those who have been accustomed to old-fashioned ways of getting a good grip of facts, and some stock of experience before proceeding to difficult investigation, are not convinced, and are inclined to doubt whether school boys and girls can be made to reason out for themselves problems which have cost for their elucidation the work of generations of men. And the logic of the process is often more than questionable. Here is an example (p. 110). The law of the conservation of mass is supposed to be established by a single experiment, which consists in burning a bit of phosphorus in a jar, and showing that there is no loss of weight.

> "Hence it must be that, *The sum of the weights of the products of a chemical change is exactly equal to the sum of the weights of the factors.* We may conceive of any chemical process as taking place in an hermetically sealed space—indeed the earth is essentially such a space —and hence this law must be universally true."

Here the process of induction is reduced to collecting a single instance, which is itself imperfect. Surely this is not to stand as an example of the methods of physical science.

One would not wish to be hard upon Prof. Cooke's little book, but with many meritorious features it does not seem to represent a great improvement upon the books referred to above. The naïve statement at the end of the introduction, that the directions can in many cases be improved, cannot be held to excuse the rough and